REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	1995, June	Final Nov 93 - Nov 94

4. TITLE AND SUBTITLE
Helicopter Simulator Sickness: A State-of-the-Art Review of Its Incidence, Causes, and Treatment

5. FUNDING NUMBERS
62785A
791
2211

6. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT NUMBER
ARI Research Report 1680

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333-5600

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
--

11. SUPPLEMENTARY NOTES
--

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release;
distribution is unlimited.

12b. DISTRIBUTION CODE
--

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14. SUBJECT TERMS
Simulator sickness
Aftereffects
Symptoms incidence
Safety risks
Prevention

15. NUMBER OF PAGES
39

16. PRICE CODE
--

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

U.S. Army Research Institute
for the Behavioral and Social Sciences

Research Report 1680

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Robert H. Wright
U.S. Army Research Institute

June 1995

U.S. ARMY RESEARCH INSTITUTE
FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency Under the Jurisdiction of the Deputy Chief of Staff for Personnel

EDGAR M. JOHNSON
Director

Technical review by

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William R. Howse
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June 1995

Army Project Number
20262785A791

Education and Training Technology

FOREWORD

The U.S. Army is increasing the use of simulators with visual systems as an economical means of developing and sustaining combat readiness. Many visual simulator users suffer simulator sickness that can reduce the effectiveness of simulator training and produce aftereffect symptoms with the potential for causing accidents. Concerns exist over the accuracy and validity of survey results on the scope of the simulator sickness problem among users of Army helicopter visual simulators. This report examines those surveys and the results with respect to incidence and severity of symptoms and potential safety consequences. It also reviews procedures available for minimizing development of simulator sickness and the potential adverse safety consequences of simulator sickness aftereffect symptoms.

This research was conducted under the training simulation research program of the U.S. Army Research Institute for the Behavioral and Social Sciences Rotary Wing Aviation Research Unit at Fort Rucker, Alabama. It was initiated as a technical advisory service and expanded as part of an internal assessment of the need for research on simulator sickness. This report addresses criterion and test control issues relating to such research. The results have been briefed internally and applied in several requests for technical advisory service.

EDGAR M. JOHNSON
Director

HELICOPTER SIMULATOR SICKNESS: A STATE-OF-THE-ART REVIEW OF ITS INCIDENCE, CAUSES, AND TREATMENT

EXECUTIVE SUMMARY

Requirement:

U.S. Army use of simulators with visual systems is increasing. However, many visual simulator users suffer simulator sickness that can reduce the effectiveness of simulator training and produce aftereffect symptoms with a potential for causing accidents. The scope of the Army helicopter simulator sickness problem is currently defined by survey instruments that use arbitrary criteria for scoring and interpretation. The objectives of this research were to assess the scope of the problem and the influencing factors of simulating sickness with helicopter visual simulators.

Procedure:

The literature on simulator sickness was reviewed, with emphasis on results reported for Army helicopter simulators. Survey instruments for defining simulator sickness effects of using Army helicopter visual flight simulators were examined for characteristics that might influence the validity of the results obtained with them. The literature and theory on simulator sickness were reviewed and analyzed to define tentative guidelines on procedures that should reduce the development of simulator sickness and the potential of accidents from simulator sickness aftereffects.

Findings:

The overall incidence of simulator sickness appears to be overestimated due to survey emphasis on minor symptoms of little actual consequence. Severe aftereffect symptoms likely to cause accidents, however, appear to be substantially underestimated. Overestimation of the problem of simulator sickness results from the survey part used just before and after flying the simulator. The scoring methods and norms used in that part give excessive weight to minor increases in symptoms and to minor symptoms. A large portion of the simulator sickness score for a pilot or simulator results from minor changes of little actual consequence.

Survey dependence on long-term memory for recall of after-effect symptoms may be expected to result in substantial underestimation of these symptoms. The survey forms require personal identification. This makes it likely that pilots will not report the more severe symptoms that, if known, could have adverse repercussions on their flying careers. This should result in underestimation of the more severe aftereffect symptoms with the greatest potential for causing accidents.

Guidelines are defined that should reduce the chances of developing simulator sickness symptoms during or after flying the simulator, and of aftereffect symptoms causing an accident. All guidelines in the literature are untested inferences derived from theory or very limited research results. The guidelines provided in this report are collated from the literature or from new guidelines derived on the same basis as those found in the literature.

Utilization of Findings:

The findings suggest caution should be exercised in using existing simulator sickness surveys as criterion measures in research on the causes and reduction of simulator sickness. Army simulator users and their supervisors should be aware that the overall scope of the problem may be overestimated by past surveys, but the severe aftereffects likely to cause accidents may be underestimated. Simulator users should adopt the guidelines for minimizing simulator sickness and the potential of accidents from its aftereffects.

HELICOPTER SIMULATOR SICKNESS: A STATE-OF-THE-ART REVIEW OF ITS INCIDENCE, CAUSES, AND TREATMENT

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HELICOPTER SIMULATOR SICKNESS: A STATE-OF-THE-ART REVIEW OF ITS INCIDENCE, CAUSES, AND TREATMENT

Introduction

A variety of physiological and psychological symptoms, mostly mild but occasionally severe, are reported by pilots after using flight simulators. These symptoms resemble motion sickness or vertigo in many respects, and are referred to as "simulator sickness" (McCauley, 1984). Simulator sickness symptoms may occur while training in a flight simulator, or its symptoms may develop shortly or some time after leaving the simulator.

Simulator sickness is a problem that has been and continues to be difficult to define. The purpose of this report is to scope the problem of helicopter simulator sickness to provide a basis for research planning. The scope of the problem of simulator sickness is examined with respect to various issues relating to defining its degree of incidence and severity during and after simulator training. The impact of suspected pilot reluctance to openly disclose symptoms is a major consideration.

Consequences of simulator sickness on effectiveness of training in the simulator, or on motivation for simulator training, are of some concern. The major concern, however, is the potential safety consequences from simulator sickness aftereffect symptoms that can occur after leaving the simulator. The nature of the aftereffects has potential for adverse safety consequences in normal flying, driving, home and recreational activities.

Two articles in the U.S. Army Aviation Digest (Crowley and Gower, Nov 88; Hancock, Apr 89) have raised the level of awareness among Army pilots of simulator sickness and its causes, and the knowledge that procedures exist for reducing its occurrence and minimizing its effects. However, these short popular articles do not represent a comprehensive approach to defining the scope of simulator sickness or how to minimize its occurrence and its consequences. Some survey research has been conducted to assess the extent of Army helicopter simulator sickness (Gower, Lilienthal, Kennedy, Fowlkes & Baltzley, 1987; Gower & Fowlkes, 1989a, 1989b; Gower, Fowlkes & Baltzley, 1989). Recommendations for minimizing simulator sickness have not been fully defined or adopted, nor their effectiveness in reducing its effects assessed.

Background

Types of Simulator Sickness Symptoms

Simulator sickness and its aftereffects are reflected in five different but related types of symptoms: general malaise,

nausea, visuomotor-cognitive, disorientation, and hallucination. The first four types were obtained by Lane and Kennedy (1988) from factor analysis of 1200 simulator sickness symptom surveys. The hallucinogenic type is added by this author to reflect occasional severe aftereffects seldom reflected in the surveys.

General malaise. These symptoms include general discomfort, fatigue, boredom, drowsiness, faintness, awareness of breathing, loss of or increase in appetite, a need to defecate, and mental depression.

Nausea. Symptoms include excessive sweating, yawning, excessive or reduced salivation, fullness in the head, pallor, burping, stomach awareness, nausea, and vomiting.

Visuomotor-cognitive. Symptoms include eyestrain, difficulty focusing, blurred vision, headache, loss of coordination, difficulty concentrating, and confusion.

Disorientation. Primarily aftereffect symptoms that include vestibular and orientation disturbances such as loss of balance, leaning and swaying, staggering, falling, dizziness with the eyes closed or open, spinning sensations, and vertigo. Vertigo sensations have included "the walls closing in," an in-flight illusory sensation of being back in the simulator and too high while landing an actual helicopter, and false perceptions of the vertical and horizontal.

Hallucination. These aftereffect symptoms include vivid flashbacks of simulator visual scene image sequences, or TV inversions or rotations (often while lying down in bed, watching TV or movies, and upon closing the eyes, but also while driving), and "detachment" experiences while driving, with the world perceived as if the eye were out of and well above the body and car.

The general malaise and nausea symptoms of simulator sickness appear to be similar to sea/air motion sickness. The visuomotor-cognitive symptoms of simulator sickness are generally similar to the malaise symptoms widely reported for prolonged use of computer video display terminals and occasionally from use of night vision aids, and sometimes from extended viewing of home TV (Morrissey & Bittner, 1986). However, the duration of viewing that produces these symptoms appears to be much shorter for simulator exposures. General malaise, nausea and visumotor-cognitive symptoms usually first occur while using the simulator, but may first appear shortly after leaving the simulator.

The disorientation symptoms of simulator sickness are generally similar to those that occasionally result from flying or from extended time on a ship or boat. However, simulators are producing these symptoms in pilots who would not normally experience them during or after flying. The evidence, though

skimpy, suggests that the rate of disorientation symptoms is much greater for simulator than it is for flying exposure. Disorientation symptoms may occur (a) only in the simulator, (b) first occur in the simulator and persist after leaving the simulator, or (c) may first occur as an aftereffect a few minutes, hours or even days after leaving the simulator. Disorientation aftereffect symptoms which occur after leaving the simulator logically have substantial potential for causing an accident.

The hallucinogenic aftereffect symptoms of simulator sickness represent a severe disruption of visual perception processes usually found only in persons considered to be severely mentally ill, or in highly intoxicated or drugged individuals. That any individuals should suffer such consequences from simulator use is a matter of concern, and the rate of their incidence, duration and causal mechanism(s) for Army simulators should be determined and removed. Hallucinogenic aftereffects primarily are reported from tens of minutes to four or five hours after leaving the simulator. They usually occur after an extensive duration in the simulator covering a large part of the day. The nature of these symptoms suggests that they could have substantial potential for causing an accident. Actions reported by pilots upon their onset, such as stopping the car until the symptoms subside, suggest a significant concern over safety.

Incidence of Simulator Sickness

Most recent simulator sickness assessments are based on survey instruments and test procedures developed by the Essex Corp. for the U.S. Navy. The validity of the results obtained with these instruments and procedures is the core issue in determining the incidence of Army helicopter simulator sickness and the actual scope of the problem, if any.

Two primary survey instruments are used: the Motion History Questionnaire (MHQ), and the Simulator Sickness Survey (Motion Sickness Questionnaire) (SSS/MSQ). Tests of balance include standing on preferred or nonpreferred leg with eyes closed, and walking heel-to-toe with eyes closed. The MHQ obtains information on subject experience with and enjoyment of various types of motion, and susceptibility to motion sickness.

The SSS/MSQ has four sections. The first obtains flying and simulator related demographic information. The second concerns physiological status, such as recent exposure to medications, alcohol, tobacco, or illness. The third consists of a four-level (None, Slight, Moderate, Severe) or No-Yes checklist of physiological symptoms and their severity. The fourth part obtains information on how the simulator was used and any functional problems with it. The first two parts are administered before using the simulator. The third part is administered before flying the simulator, after flying the simulator, and could be used in the middle of simulator use. The

fourth part is completed after using the simulator. The balance tests, if used, are administered before and after using the simulator.

Scoring the SSS/MSQ first involved defining, for selected symptoms and their severity, the ratings as either MAJOR, MINOR, or OTHER effects. These then were converted to sickness severity scale values by a defined set of criteria. For example, criteria for scale value 3 are "ONE MINOR plus OTHER symptoms reported," and for a value of 5 "ONE MAJOR and TWO MINOR symptoms." The scale values which result provide a basis for relative comparisons of simulator sickness incidence/severity between simulators or between or within subjects. The scores allow comparison with the average or range of scores. However, no basis exists for determining whether a "real problem" with simulator sickness exists for a given score (except for a zero, all "None's" score). Generally, the scores have been interpreted to suggest a basis for concern when they are above average. In developing scoring procedures, a simulator sickness incidence rate of 13% was obtained when a high criterion for discomfort was adopted, and 70% when a low criterion was adopted (Kennedy, Lilienthal, Dutton, Ricard, & Frank, 1984). The scoring procedures finally adopted resulted in a "sickness" incidence rate near the middle of this range (a score of 3 or above). Recently, an improved relative scoring method has been adopted based on the results from factor analyses, (Kennedy, Lane, Berbaum, & Lilienthal, 1993).

A series of reports (Gower et al., 1987; Gower & Fowlkes, 1989a, 1989b; Gower et al., 1989) document Army helicopter simulator sickness incidence/severity by type of symptom. Using a score reflecting a composite of incidence and severity (Lane & Kennedy, 1988) they compare levels of incidence/severity in Army simulators with that in various Navy simulators. Their results (see Figure 1) indicate that Army simulators produce somewhat more severe simulator sickness symptoms than does the typical Navy simulator. In the figure, an overall sickness severity scale value of 100 (a transformed score equal to 0.0 for the basic score described in the paragraph above) is supposed to equate to zero incidence of simulator sickness. Pre-use simulator sickness severity scores for Army simulators, however, were all significantly above 100. After using the simulator, scores increased significantly above the pre-use values. The tests of balance all indicated a decrease in postural equilibrium after using the simulators. Among Army simulators the UH-60 is found to be the worst in producing simulator sickness symptoms, followed, respectively, by the AH-1, AH-64 and CH-47 simulators. The UH-60 simulator is close to the Navy's SH-3 simulator that has the highest reported incidence/severity of simulator sickness symptoms.

The total incidence of simulator sickness is not reported for the AH-1, CH-47 and UH-60 simulators (Gower & Fowlkes, 1989a, 1989b; Gower et al., 1989), although approximate incidence can be appreciated by bar lengths to those for the AH-64 and SH-3 on the

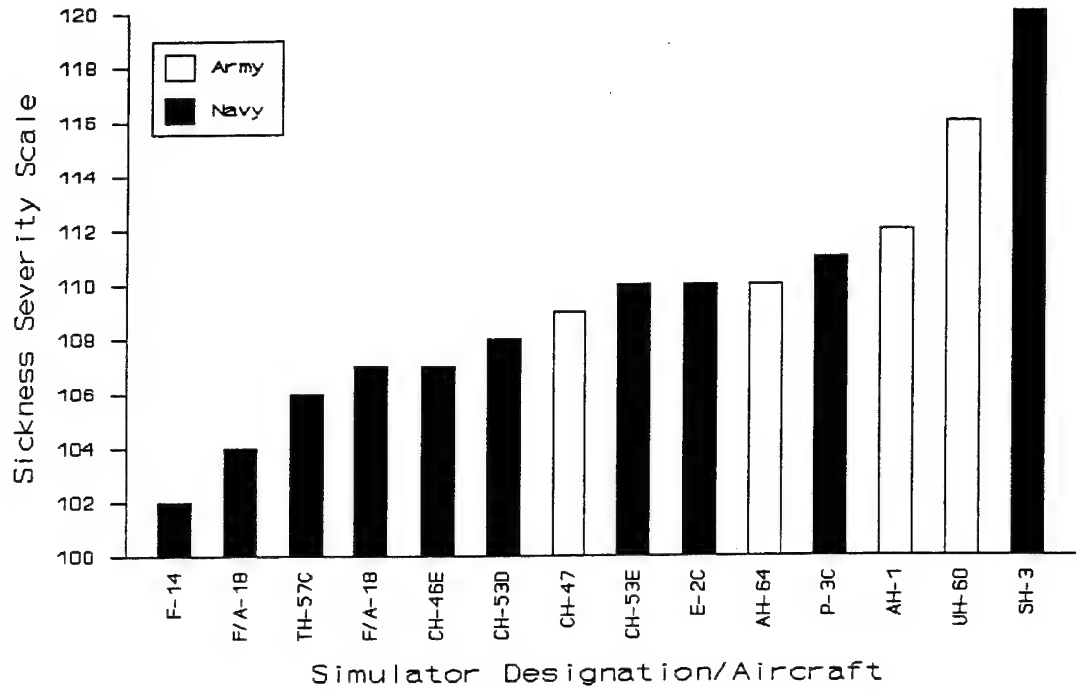

Figure 1. Relative simulator sickness for users of Army and Navy flight simulators as defined by the total severity scale of the Simulator Sickness Questionnaire (from Gower & Fowlkes, 1989a).

"severity" scale in Figure 1 (a composite of incidence and severity). Total incidence for both student and experienced pilots was reported as 44% in the AH-64 flight simulator, and 57% for experienced pilots flying in the rear pilot station (the criterion for an "incidence" of simulator sickness is not described, but is presumed to be a basic score of 3 or above). These AH-64 values and the figure relative bar lengths for the UH-60 and AH-64, suggest total simulator sickness incidence, as loosely defined, might exceed 75% for experienced pilots actively flying the UH-60 simulator.

In contrast, severity of simulator sickness symptoms while using the simulator and afterward seem to be mild for most of the Army pilots who report any symptoms. Only a few percent of pilots (8% for AH-1, 1% for UH-60) report their simulator sickness discomfort hampers training to any degree (Gower & Fowlkes, 1989a, 1989b). However, reported percent of time on types of training in the Gower and coworker (Gower et al., 1987; Gower & Fowlkes, 1989a, 1989b; Gower et al., 1989) reports suggest many pilots avoid a lot of training time on maneuvers likely to induce simulator sickness. These reports do not discriminate between symptoms for which onset first occurs in the simulator, immediately after leaving it, or hours or days later. Neither are the duration of symptoms nor repeated symptom episodes reported. Using a summary item (Have you ever experienced simulator sickness or discomfort, or any other aftereffect?) in the Motion History Questionnaire, Baltzley,

Kennedy, Berbaum, Lilienthal and Gower (1990) found 50% of AH-64 simulator users reporting they had experienced simulator sickness or discomfort symptoms. Ungs (1987) also found 50% of Coast Guard pilots reported they suffered some sickness or discomfort during or after simulator training.

Adaptation to the Simulator; Readaptation to Actual Flight

There are a large number of anecdotal comments from full-time simulator instructors that suggest their initial simulator sickness adapts over a period of a few days to a few weeks. For some simulator instructors all symptoms may disappear completely, and for some slight or tolerable symptoms may persist indefinitely. Simulator instructors routinely flying Army flight simulators on a full-time, daily basis do not appear to have any significant simulator sickness problems, nor do there appear to be symptoms that interfere significantly with instructional effectiveness. These views are supported by data obtained from Navy helicopter pilots flying 40 to 60 minute periods in a research simulator for three consecutive days. Their simulator sickness symptoms decreased substantially each subsequent day, to a level on the third day about one-third that for the first day (Uliano, Lambert, Kennedy & Sheppard, 1986). Kennedy et al. (1993) report that their improved Simulator Sickness Questionnaire 75th-percentile scores decline in a near-linear fashion from 15 on the first to zero on the 6th simulator flight.

Army instructor pilots often may intermingle simulator and actual helicopter flying during the same day. Existing evidence suggests actual flight following the simulator has potential for reduced flight safety for a small percent of instructors. Adaptation to one simulator as an instructor will not necessarily transfer to a different simulator, and may actually increase the risk of simulator sickness. An instructor in a UH-60 simulator, with absolutely no simulator sickness problems, reported that he became violently ill within a few minutes in a different type (CH-47) of simulator. Repeated attempts to fly the CH-47 simulator all produced the same reaction, while no problems existed when the UH-60 simulator was flown. This anecdote strongly suggests some simulator-specific causal factors in the development of his simulator sickness.

It is not clear how simulator sickness symptoms adapt for the schedules of infrequent simulator use typical of many Army users, or whether the symptoms, if present initially, adapt at all. A six-month interval between a few periods of simulator use over one or several days is a common schedule. User comments suggest that most pilots find simulator sickness symptom probabilities and severities decline as recent experience with the simulator increases, as described for instructors and Navy pilots above. However, most comments indicate that after several months away from the simulator, the level of symptoms will be about the same as for the first original simulator flight. The symptom level usually is reported to decline with each subsequent

simulator period over the next few days. The results of Uliano et al. (1986) and Kennedy et al. (1993) reviewed above confirm these pilot conclusions. It seems that most pilots need to re-adjust in some manner to the simulator in order to minimize development of simulator sickness symptoms.

Two to five days between the first and second simulator flights were found to reduce second flight 75 percentile sickness scores to one-third of those for second flights on the same day, for one day between, or for six or more days between flights. Kennedy et al. (1993) suggest "perhaps this interval is long enough to avoid carryover of symptoms from one exposure to the next and short enough to retain whatever adaptation to the simulator has been gained." Their graph shows an abrupt drop from 1 day to "2&3" days delay between flights, and an abrupt climb from "4&5" days to 6 days delay between simulator flights. Their results suggest some remarkably specific time gating of symptoms carryover and simulator adaptation effects.

Some aspects of perception seem to be altered by the simulator, and to re-adapt to veridical for the actual flying and real world only in a gradual fashion. A gradual reduction in simulator sickness was found across 10 flights by student aviators in the AH-64 simulator (Gower et al., 1987). A gradual reduction in postural stability also was found across the 10 flights. Their data suggests that the price paid for adaptation to the simulator is decreased equilibrium. They conclude that the decreased equilibrium could result in compromises to safety both on the ground and in flight.

Numerous pilot comments suggest that the adaptation to the simulator that reduces simulator sickness, through daily training periods, is not instantly reversed upon resumption of actual flying. Many pilots report a gradual re-adaptation to real-world perceptual processes. There can be a sudden unanticipated shift back to the simulator perceptual process while flying or engaged in ground activities. This gradual return and the perceptual shifts appear to be similar to those frequently observed after a change in eyeglass prescription. Height, distance and motion perceptions may be altered from veridical, and take several days or more to return to normal consistently. This same gradual adjustment in perception is also found in virtually all of the research on perceptual modifications (such as with reversing prisms), both at its onset and termination (Welch, 1978; Gonshor & Melvill-Jones, 1976).

Individual Factors Contributing to Simulator Sickness

There are a variety of individual factors that can predispose or increase the probability of development of simulator sickness or its aftereffects. These individual factors include how the simulator is used, physiological and psychological states upon entering the simulator, flying experience, recent sensitizing activities or experiences, and adaptation to the simulator.

How the simulator is used. The length of time spent in the simulator appears to be among the factors most highly related to the occurrence of simulator sickness or its aftereffects. In a preliminary statistical analysis of relationships between simulator sickness and simulator characteristics and use factors, mission duration was found to be related to sickness symptoms more than twice as highly as any other factor included (Casali & Wierwille, 1986). Kennedy and Fowlkes (1990) found a 0.50 correlation between duration of simulator use and the Simulator Sickness Questionnaire total severity score. As continuous time in the simulator extends beyond two hours, rate of incidence of simulator sickness appears to increase rapidly. One or several breaks during a simulator session seem to reduce incidence and severity of simulator sickness. Time-scheduled breaks appear to help, but taking breaks at first onset of symptoms, onset of significant symptoms, or after or between known highly provocative maneuvers may be even more effective as a preventative. Conducting vigorous maneuvers, especially when close to the ground, and flying close to the ground at high speed are considered to be conducive to development of simulator sickness symptoms. Extended periods of such maneuvers should be very likely to elicit simulator sickness. Minimizing and spacing these maneuvers known to be provocative can be used as an individual means of reducing chances of simulator sickness. Unanticipated use of the "freeze" feature in the simulator can be highly conducive to development of simulator sickness. Adoption of procedures to alert other persons to use of freeze, and avoiding looking at displays when it is used, should help reduce the adverse effects of using freeze.

Physiological and psychological states. The physiological and psychological states of an individual upon entering the simulator can have a major influence on the chances of developing simulator sickness. An individual already suffering from motion sickness would be very likely to suffer an increase in severity or types of symptoms from flying a simulator. Pilots reporting symptom levels considered "sick" (3 or higher on the basic scale) prior to using the simulator are excluded from the statistics on simulator sickness. A variety of physiological symptoms can predispose an individual to develop simulator sickness. Some of these are hangover, headache, visual fatigue, flu, colds, sinus infections, or virtually any infection causing a fever. Some psychological symptoms likely to predispose include high personal stress at home or work, sleep loss, mental fatigue, fear of failure, and a recent vertigo episode.

Flying experience. The more flying experience pilots have, the more likely they will experience simulator sickness. Most of the incidence surveys suggest that highly experienced pilots suffer simulator sickness at a rate of about 150% of that for trainees or pilots with limited flying experience. It is believed that extensive, very recent flying experience may sensitize a pilot to development of symptoms, and some data (Gower et al., 1987) suggest that the more experienced pilots who

fly the simulator may be more prone than those not responsible for flight control.

Recent sensitizing activities. Any recent exposure to situations conducive to motion sickness, even though no indications of such symptoms exist, theoretically can be expected to increase chances that simulator sickness will develop (Kennedy & Fowlkes, 1990; Triesman, 1977). Long periods in prior days or hours on ships, trains, cars, boats or aircraft, will continually expose the vestibular and visual senses to cues that theoretically may temporarily increase susceptibility to motion sickness and simulator sickness. Even though no acute or even minor symptoms may exist from this recent exposure upon entering the simulator, a heightened predisposition in the perceptual senses is hypothesized that may be expected to increase the likelihood of developing simulator sickness. An extended period of viewing a computer video display terminal shortly prior to simulator training is also suggested as likely to predispose to development of simulator sickness. The malaise many people develop from extended use of video display terminals shares many of the symptoms of simulator sickness (Morrissey & Bittner, 1986). According to the theory of Kennedy and Fowlkes (1990), these similar symptoms should promote simulator sickness.

Adaptation to the simulator. As discussed above, recent prior training in the same type of simulator reduces the probability of developing simulator sickness during or after subsequent training periods. Conversely, the first training period following an extended absence from simulator training is most likely to produce simulator sickness or its aftereffects. This suggests scheduling of simulator periods and the maneuvers trained during them could be arranged to minimize the risk of developing simulator sickness. Initial training periods following an extended absence from flying a simulator should be shortened, and less provocative maneuvers selected for training during them. Two well-separated short training periods during the first day might be desirable. As simulator adaptation builds up, longer training periods, or the more provocative maneuvers in subsequent training, should produce considerably less risk of developing simulator sickness than if similar training is conducted during the first period.

Effects of Simulator Sickness--Types of "The Problem"

The problem of simulator sickness is reflected in four primary types of consequences that are of concern: (a) adverse effects on training in simulators, (b) adverse effects on willingness to train in simulators, (c) adverse effects on transfer of simulator training to the aircraft, and (d) adverse effects on safety following simulator training. There is some evidence supporting a modest negative effect from the first. The second is primarily a logical conclusion from the discomfort of simulator sickness. The third is a logical conclusion from indirect research evidence and anecdotal comments of pilots. The fourth is a conclusion by researchers that reported simulator

aftereffects logically should be expected to have some negative safety impact.

Effects on simulator training. The data of Gower and Fowlkes (1989a, 1989b) indicate a few percent (1% for UH-60; 8% for AH-1 simulators) of user pilots feel there is some degree of interference with training effectiveness from simulator sickness. It is reasonably clear that simulator sickness effects while in the simulator are relatively minor on an overall basis in terms of their effect on training. This situation may be due to most pilots using the simulator in a manner which minimizes development of simulator sickness. Simulator sickness may be significant for a few individuals, and these individuals are likely to be the more experienced and capable pilots of a unit. Given the discomfort from simulator sickness symptoms, an increase in the frequency and duration of non-training breaks during a training period can be expected. In addition, the data of Gower and his co-workers (Gower et al., 1987; Gower & Fowlkes, 1989a, 1989b; Gower et al., 1989) indicate that excessive time appears to be devoted to tasks and conditions that are of limited training value, but which can be expected to provoke minimal symptoms of simulator sickness.

Effects on willingness to train in simulators. The discomfort of simulator sickness produces a reluctance, in susceptible pilots, to train in flight simulators, or to train in them on the tasks most likely to provoke simulator sickness. Although data directly substantiating this effect do not exist, nearly all researchers on simulator sickness are confident it has a negative impact on simulator training effectiveness. It is likely an indirect consequence of simulator sickness on motivation to train, or to train on the more provocative tasks, has more actual adverse impact on training than do the direct effects of the simulator sickness symptoms.

Effects on transfer of training to the aircraft. Most pilots adopt certain techniques or patterns of behavior for flying the simulator that are not appropriate for actual flight. At least in part these altered behaviors are adopted to reduce onset or level of discomfort of simulator sickness. Many pilots report they avoid the more vigorous maneuvers and head motions in the simulator that are likely to produce simulator sickness. For the most part, however, pilots probably adopt different techniques for flying the simulator in order to attain better performance in it. Reduced transfer of training can result if behavior or performance is altered. It has the potential for negative transfer of training when pilots have to unlearn the flying techniques, visual perceptions, or mental processes used in the simulator upon return to the actual aircraft. The reduction in simulator sickness that occurs with repeated but spaced simulator training over several days (Uliano, et al., 1986), suggests that visual-motion sensory or mental processes adapt to simulator cues with these repeated simulator exposures. As discussed above, it is quite likely these adapted processes may require a period of readaptation to actual flight, as is

found to be needed in sensory alteration research such as when vision reversal prisms are removed (Gonshor & Melvill-Jones, 1976).

One concludes negative transfer from simulators to the actual aircraft has two primary causes. One is altered behaviors and flying techniques in the simulator in order to fly the simulator better or to minimize simulator sickness. The other is internal adaptive alteration in visual-motion sensory or mental processes which occur with simulator use to minimize development of simulator sickness.

While all evaluated Army simulators have demonstrated positive transfer of training for initial transition to the aircraft, their positive transfer for proficiency training of experienced pilots is uncertain and currently undemonstrated for many tasks. Their positive transfer for initial transition may have been due entirely to the procedural tasks. It is uncertain whether any positive transfer of training from the simulator to the aircraft exists for sustainment training of experienced pilots on psychomotor tasks such as emergency touchdown maneuvers (Kaempf & Blackwell, 1990; Kaempf, Cross & Blackwell, 1989).

Effects of aftereffects on safety. Adverse effects on safety from simulator sickness aftereffects appear to represent a distinct risk that should be minimized. Researchers on simulator sickness appear to hold this conviction, even though accident data supporting it do not yet exist. While only a small percent of pilots are likely to suffer aftereffects of simulator use, any increased safety risks are unacceptable. More experienced pilots, given the most responsible flying duties, are considered at greatest risk of suffering simulator sickness aftereffects which can reduce flight safety.

Adverse effects on safety from simulator sickness aftereffects exist not only for flying but also for driving, walking, running, and standing. Pilots have lost their balance while walking and upon closing their eyes while showering. Falling off a barstool (before the first sip) has even been reported as an aftereffect, so perhaps the risk extends even to sitting. A number of aftereffect reports indicate symptoms while driving that necessitated pulling off the road and stopping until they subsided. Simulator sickness aftereffect episodes while riding a motorcycle or bicycle would be expected to have potential for severe consequences. Reasons why unsafe behaviors or accidents are unlikely to be attributed to simulator sickness aftereffects are discussed in a later section of this report.

Theories of Cause of Simulator Sickness

Theories on the causes of simulator sickness focus on some combination of the physical stimuli, sensory processes, and central nervous system (CNS) processes as they relate to the physiological mechanisms known to be involved in motion sickness (McCauley, 1984). Physical stimuli in the simulator which are

not possible or unlikely to exist in the actual world form the primary basis of simulator sickness theory.

Cue conflict theory. It is generally accepted by the research community that the primary causes of simulator sickness are conflicts within and between motion and visual cues, or conflicts between actual flight and the simulator in sensory cues or/and control responses (McCauley, 1984). This viewpoint is termed the "cue conflict" or "sensory conflict" theory of simulator sickness. An individual predisposition and specific simulator characteristics may contribute somewhat by creating sensory conflicts that result from inappropriate interpretation of motion and visual cues. These cue interactions are regarded as the primary factors causing simulator sickness. Cue conflicts arise when the magnitude, timing or flow of motion and visual cues are not in accord with each other or with past flight experience.

CNS toxic reaction to decorrelated sensitive channel energy. This theory accepts the main tenets of cue conflict theory, but adds emphasis to the concept that the CNS reacts to these conflicts in a manner akin to the build-up of a toxic reaction characterized in final stages by emesis, or vomiting (Kennedy & Frank, 1985; Treisman, 1977). Also emphasized is the concept of energy at the frequencies around 0.2 Hz most likely to cause motion sickness, and the decorrelation of this energy between and within motion and vision channels. A primary emphasis of this theory is the polygenic and polysymptomatic additive nature of build-up of the toxic reaction. This additivity concept implies any existing symptoms that predispose toward emesis (such as colds or flu, sinus congestion, hangover, or recent flying in turbulence) will sensitize the pilot and make simulator sickness a more likely event.

Time Course of Aftereffects

Two reports (Ungs, 1987; Baltzley et al., 1990) provide limited initial documentation of the time course of decline in simulator sickness aftereffect symptoms. Ungs (1987) had Coast Guard pilots look for and report on aftereffect symptoms in the days immediately after completing simulator training. Baltzley et al. (1990) used long-term recall based on the Motion History Questionnaire item and sub-items: "Have you ever experienced simulator sickness or discomfort (or any other aftereffect)?"

Ungs (1987) found that 4.6 percent (9 of 196 returned questionnaires) of Coast Guard pilots report aftereffects of simulator sickness persisting for more than two days. Three of these nine pilots (1.5% of the 196) reported their aftereffect symptoms resulted in difficulties in resuming aircraft flying. Two (1%) pilots reported symptoms that continued for a week or more, and one of these reported a disturbance in his sense of balance that lasted for three weeks after his last simulator flight. The two days or longer-lasting aftereffect symptoms

reported by the Coast Guard pilots were not insignificant in their potential safety impact:

- Two had "visual flashbacks of distortions,"
- Two had "a continued sense of detachment from reality,"
- Three had "a disturbance in balance (leans, stumbling, etc.) or hand-eye discoordination," and
- Two had "persistent difficulty in concentrating and sleeping."

Baltzley et al. (1990) also report a 4.6 percent incidence rate of aftereffect symptoms for helicopter simulator users, but for just 6.1 <u>hours</u> or more after leaving the simulator. This differs from the Ungs (1987) time of two days for the same percentage by a factor of eight! The long-term recall used by Baltzley et al. and the near-immediate recall used by Ungs is probably the basis for this major time difference for the same rate of aftereffect symptoms.

Gower and Fowlkes (1989a, 1989b) report that some simulator sickness symptoms persist beyond 6 to 8 hours after using the simulator for about 8 percent of Army pilots, and that for some pilots symptoms may persist for one to two days.

There are numerous anecdotal accounts in simulator sickness research reports of aftereffect symptoms which occur hours or days after leaving the simulator. For some pilots, long-term symptoms may persist that existed upon leaving the simulator. Others may have symptoms occur after an extended period that is symptom-free. Usually, pilots who have aftereffect symptoms following symptom-free periods, also had sickness symptoms in or immediately after leaving the simulator. There are a few pilots, however, who have experienced delayed aftereffect symptoms without any known prior symptoms.

Ungs (1987) found that 8 of the 9 pilots (89%) who suffered long-term aftereffect symptoms for more than two days after using the simulator had also suffered sickness symptoms while in the simulator. In contrast, only 48% of the 187 pilots who did not suffer long term aftereffects had sickness symptoms while in the simulator or immediately after. This finding suggests that pilots who suffer no simulator sickness symptoms while in the simulator or immediately after are relatively unlikely to suffer long-term aftereffect symptoms.

These results indicate long-term aftereffects may occur for a few pilots well beyond the tens of minutes to several hours that symptoms typically persist for most pilots who experience them. For some pilots, they can last well beyond the 6 to 12 hours or next day that has been suggested as safe in some proposed guidance and regulations changes.

Reluctance to Report Aftereffects

Pilots historically have been reluctant to divulge symptoms of simulator sickness; especially its more severe aftereffects. For many years, the problem went unrecognized in all services because of this reluctance. Problems with airsickness or vertigo can definitely have an adverse impact on a flying career. For example, "Doc, the room kept inverting on me last night," is not a prudent thing to report to the flight surgeon if one values a career in aviation. Most pilots probably also know that their symptoms will disappear in a few hours or, at most, a day or two.

Although relevant data are lacking except from occasional researcher interview comments, it is believed that most major simulator sickness aftereffect symptoms are not reported to unit flight surgeons. It is suspected that nearly all of the really severe aftereffect symptom episodes are never reported officially, nor even casually to peers.

Some reports of major simulator sickness aftereffects have been obtained from surveys or from flight surgeons. However, most reports of severe aftereffects have been obtained from one-on-one interviews by researchers. Researchers report the really severe aftereffect episodes usually are not divulged unless a rapport is established which convinces a pilot the researcher would not, and could not be made to, disclose their identity. It is unlikely survey or similar data collection techniques on simulator sickness aftereffects, requiring pilot identification, have produced accurate results.

Most incidence/severity surveys used in the past, while reported to be anonymous, have required pilots to record their name, rank, date, unit, and instructor pilot if in qualification training (see Appendix A). A recent survey version requires the social security number, in addition, and codes each page with it instead of an anonymous code. If pilots completing the surveys have experienced major symptoms, they must decide whether to perhaps risk their flying careers on the assurances of an unknown researcher. Survey cover pages assure pilots all personal data will be removed and the data identified only by a coded serial number. Many pilots may wonder, however, why the personal information is requested if it isn't going to be used.

Few pilots would have high confidence in the absolute anonymity of their survey contents upon providing such self-identification. Without high confidence in their anonymity, it is likely many pilots have failed to report those symptoms which could adversely affect their flying careers should they be disclosed. Without total pilot confidence in the absolute anonymity of their survey results, from a research standpoint, the results must be considered suspect with respect to the incidence and severity of the simulator sickness symptoms which are reported. Truly anonymous survey techniques appear to be essential for obtaining accurate data on the simulator sickness problem, and to date they have not been used.

Safety Risks From Aftereffects

The reluctance to report simulator sickness aftereffect symptoms discussed in the prior section may be expected to apply in even greater degree to reporting of accidents or safety incidents that might result from such symptoms. Severe repercussions on their flying career would be quite likely for any pilot who acknowledged simulator sickness aftereffects as contributing to a consequential accident. Data indicating such a causal relationship, if any, therefore, are most unlikely to be developed unless the risk of severe adverse career consequences for reporting such causal symptoms is fully eliminated.

No documented relationship between simulator sickness aftereffects and accidents has been found. Only isolated anecdotal aftereffect episode accounts by pilots are reported in surveys, in verbal discussions with researchers, or in secondhand accounts by other observers. No direct linkage of aftereffects with accidents has been reported, except for a secondhand account by a non-involved observer. Some of the episodes which have been reported include (after Baltzley et al., 1990; Gower et al., 1987; Kaempf, 1990; Kellogg, Castore & Coward, 1980; Kellogg & Gillingham, 1986; Kennedy et al., 1984):

- Dizziness, vertigo and slight nausea. I fell down the stairs.
- Vertigo and nausea, motion sickness driving my car afterwards.
- Saw terrain board while driving car. Lasted four hours.
- Fell on motorcycle a few blocks away after six hours in simulator.
- Visual illusion of movement after; lasts until bed and then four hours.
- I tend to drive fast after flying a simulator.
- Problems walking straight after 4-6 hours in simulator.
- Disequilibrium occurred in movie theater when scene panned a landscape.
- Episodes of the TV inverting four to six hours after last flight.
- Episodes of the TV spinning four to six hours after last flight.
- Had to pull off road because of disorientation sensations.
- Had to pull off road because of detachment episode (eye well above car).
- Trouble landing due to illusory feeling of being in simulator.
- 12 hours after, felt spinning and movement sensations when closed eyes.
- Sensations of spinning or rotation up to 10 hours after.
- Fell against wall 3.5 hours after flight.
- Two hours after felt the walls were moving in and became disoriented.
- Can close eyes and "flashback" to visual scene in cockpit.

- Vivid flashbacks of the simulator visuals in maneuvering sequences.
- Strong feeling of being in small rowboat on the ocean for 10 hours after.
- Fell off barstool before first drink shortly after long day in simulator.
- Kinesthetic sensations of maneuvering for extended time after.

A potential for many of the above aftereffect episodes to result in injury-producing accidents is evident. They simply have to occur at the "wrong" time for an accident to result. Many of the episodes appear to be related to circumstances where high visual angular rates of self-motion, or motion in a viewed image, exist as triggers to the episode onset. Risk of a severe accident may be expected to be high whenever disorientation or hallucinogenic aftereffect episodes occur while moving at high velocities. A trigger for the aftereffects episodes is high visual flow rates such as flying near the ground, driving a car, or riding a bicycle or motorcycle.

Reducing the Safety Risks From Aftereffects

There are a variety of things pilots and their supervisors can do to reduce safety risks from the aftereffect symptoms of simulator sickness. These include (a) avoid risky after-simulator activities, (b) reduce aftereffects and their severity through prevention of sickness in the first place, (c) avoid situations conducive to onset of aftereffect symptoms, (d) anticipate aftereffects onset and plan coping strategies for them in advance, (e) assess own potential for the onset of aftereffect symptoms, and (f) prohibit risky activities for specified time periods following the use of simulators.

Avoid Risky After-Simulator Activities

Avoiding risky activities following simulator training is one of the easiest and most effective ways of precluding accidents or injuries as a result of simulator sickness aftereffect symptoms. With a little advance planning, it should usually be possible to avoid most activities that entail risk for several days after using the simulator. Risky activities should be avoided in and just after leaving the simulator. Time periods suggested for avoiding flying activities following use of a visual flight simulator have been from 6 to 12 hours, or in some cases, several days.

When risky activities cannot be avoided, it is recommended they be deferred as long after using the simulator as practical. Risky activities are defined as any activity likely to result in an accident from loss of valid spatial awareness or the ability to maintain an intended spatial state. Following are some of the higher risk activities in the general order of their possible adverse consequences:

1. Flying an aircraft as pilot in command and on the controls.

2. Driving a passenger or load-carrying vehicle such as a van, bus or truck.

3. Riding a motorcycle.

4. Riding a bicycle.

5. Driving alone in a car or off-road vehicle.

6. Serving as an aircraft pilot, but not on the controls or as pilot in command.

7. Climbing or other activities that depend on balance.

8. Walking up or down stairs or ramps, or standing on balconies.

9. Running, jumping or any vigorous sport.

10. Parachute jumping.

11. Springboard diving or diving from a height into water.

12. Underwater swimming or scuba diving.

13. Walking on a hard surface.

14. Showering with the eyes open or closed.

To minimize the risk from loss of balance, for at least several days after using a visual flight simulator, a special effort should be made to use all handrails provided on stairs, ramps and balconies. In hallways and other areas without handrails, it is recommended that one walk close to the wall and lightly touch it as a means of assuring balance is maintained.

It is recommended that pilots who have received visual flight simulator training try to avoid all of the above risky activities while departing the simulator facility and during the first few hours afterward. If these activities cannot be avoided, pilots should be especially cautious and avoid situations and actions known to be conducive to onset of simulator sickness aftereffect symptoms.

<u>Prevention: Apply Guidelines to Reduce Risk of Aftereffects</u>

Preventing simulator sickness symptoms from developing in the first place is by far the best approach for reducing the safety risks that result from them. "An ounce of prevention is worth a pound of cure" definitely applies. Applying the guidelines found in Appendix B or the Navy Simulator Sickness Field Manual (1988) for reducing incidence and severity of

simulator sickness symptoms represents one of the best ways of reducing the potential for safety risks associated with aftereffect symptoms. When these guidelines are applied chances of suffering any symptoms are reduced, and the severity of symptoms should be reduced. Applying these guidelines also should reduce the duration of symptoms, when they occur.

Avoid Situations Conducive to Aftereffect Symptoms

Avoiding situations conducive to elicitation of simulator sickness aftereffects can help reduce the occurrence of symptoms and, consequently, the related safety risks. Generally, any situation where cues to self-motion exist, especially visual cues, will be conducive to development of aftereffect symptoms. High flow rate visual cues are particularly provocative of symptoms of simulator sickness aftereffects. Pilots need to be extra cautious when high flow rate visual cues exist inherently in risky activities, which is often the case if flying, driving, running, or walking is involved.

The high visual flow rates that occur as a result of quickly moving the head and eyes can trigger onset of symptoms. The distorted motion cues (Brickner, 1989) that result from head motions when wearing night vision devices, and momentary distortions in spatial cues of TV images, strongly suggest these devices could trigger simulator sickness aftereffect symptoms. Susceptible individuals should, therefore, attempt to move the head and eyes slowly during periods they believe themselves to be at risk.

TV and movies containing scenes with high rates of motion are likely to trigger aftereffect symptoms, but at-risk activities are unlikely when viewing them. Caution is advised, however, should such scenes occur while moving to find a seat in a darkened theater.

It is strongly recommended that riding motorcycles and bicycles be avoided completely immediately after using the simulator, since they require good balance while imposing high visual flow rates. The high visual flow rates are likely to provoke aftereffect symptoms, and the symptoms are likely to produce loss of the sense of balance or spatial awareness.

The high angular rate visual flow perceptions of the moving streams of water in a shower are a likely trigger source for aftereffect symptoms. Keeping the shower head behind one's own head, so one is not looking across the flow, should help reduce the flow rates and risk of onset of an aftereffect episode.

Anticipate and Plan Coping Strategies for Onset of Aftereffects

The risks from simulator sickness aftereffects can be reduced by anticipating their onset, and by advance planning of strategies for coping with the symptoms, should they occur. One should anticipate potential symptom onset whenever engaged in a

situation where high visual motion rates exist. Coping strategies will vary with the particular activity being performed, and its particular circumstances. If flying, the copilot should be alerted for potential quick transfer of control. If driving, one should try to stay in the right lane to facilitate pulling off the roadway and stopping. If walking or standing, one should use or be aware of handrails, walls or other aids to help in maintaining balance.

Self-Assessment of Own Potential for Onset of Aftereffects

A process of self-assessment can be used to help estimate one's potential for onset of aftereffect symptoms. Any of the symptoms of simulator sickness or its aftereffects should be regarded as an alert signal for possible onset of more serious symptoms. Any symptoms which occur in the simulator or just afterward suggest a chance for later aftereffect symptoms that could occur during high risk activities. One can test one's proneness to symptom onset by deliberate exposure to situations known to be provocative but safe. These can include:

1. Closing the eyes for detection of any hint of visual flashbacks to the simulator. Being alert for any hint of flashbacks prior to opening the eyes in the morning.

2. Being alert for any partial or momentary sensation of loss of balance during body or head motions likely to disturb balance.

3. Attention to visual flow cues while another pilot flies and turns at high speed close to the terrain.

4. Attention to visual flow cues while another person drives a car at highway speeds. Looking at the roof lining will accentuate perception of flow, and flow rates can be increased by looking at the roadway close to the car.

Individual pilots must assume responsibility for self-assessment of their own potential for suffering from simulator sickness aftereffects. Current evidence indicates that the potential for suffering aftereffect symptoms is a complex combination of many factors such as:

- simulator used,
- duration of use,
- maneuvers performed,
- maneuvers performed close to the ground,
- flying experience,
- time since leaving simulator, and
- activities and situational circumstances after leaving simulator.

Each pilot should build up an experience base on what his simulator limitations are without suffering aftereffect symptoms.

Whenever time in the simulator is increased, or the time spent flying provocative, close to the ground or vigorous maneuvers is increased, pilots should be cautious in their after-simulator activities to be sure they are able to tolerate this increased use of the simulator. Whenever a different or new type of simulator is used, pilots should initially be cautious in their after-simulator activities until they are confident different adjustments or characteristics have not produced or increased simulator sickness aftereffect symptoms.

Pilots should be aware they are at much greater risk of developing simulator sickness and its aftereffects during the first training period following an extended layoff from simulator training. Risks will be especially high if this first period is lengthy, or if numerous highly provocative maneuvers are flown. Previous simulator training without adverse effects is in no way indicative of the training that can be tolerated for a new sequence of training periods.

Prohibit Risky Activities for a Time After Using Simulator

One approach for reducing the safety risks from simulator sickness aftereffects is by administratively restricting selected training activities. For example, restriction from flying actual aircraft for 12 hours after leaving visual simulators is an example of this approach. Such a restriction should preclude a large portion of the potential risk in flying activities from the aftereffect symptoms of simulator sickness. However, it fails to deal with the probably greater risks from aftereffects in other types of activities. Ungs (1987) survey data trends suggest 10 to 20% of pilots may be expected to suffer simulator sickness aftereffects 12 hours or longer after flying the simulator. Care must be taken in phrasing and implementing such an administrative restriction that it does not have the effect of increasing safety risks in other activities. Administrative restrictions just on flying should not leave the impression that all other activities are safe from risks from simulator sickness aftereffects.

Real risks exist from the visual aberrations or loss of balance aftereffect symptoms when driving a vehicle or riding a motorcycle or bicycle. A prohibition on riding motorcycles or bicycles appears warranted for some period of time after using a visual simulator. For the 10 to 20% of pilots that can be expected to suffer simulator sickness aftereffects for longer than 12 hours, special care must be taken that they and their passengers are not put at risk by self or supervisory presumptions that all pilots are completely free of aftereffect symptoms after 12 hours. Restrictions should be worded in a manner that precludes inducing false expectations of safety for those individuals who happen to be prone to long-duration aftereffects.

Conclusions

This review indicates that the scope of the Army simulator sickness problem is uncertain. Incidence of about 50% appears probable for some simulator sickness symptoms, usually mild, during or just after training in Army helicopter visual simulators. It is concluded that the survey methods used overestimate incidence by giving excessive weight to minor symptoms of little actual consequence. However, the surveys appear to substantially underestimate the more severe aftereffect symptoms which are likely to be a safety issue. Lack of truly anonymous surveys, in combination with the potential for adverse flying career consequences, are suggested as reasons why the more severe symptoms and aftereffects may not be reported accurately.

A variety of guidelines and procedures are available which ought to reduce the incidence of simulator sickness if they are applied consistently by Army simulator users. Even though there are no additional costs nor time loss, guidelines and procedures to reduce the frequency and/or severity of the simulator sickness have not been adopted. If the recommended preventive techniques were used, the effectiveness of the visual flight simulator would be enhanced. They should have some positive effects in terms of willingness to train in simulators, the percent of actual training during a simulator period, and the percent of time which can be spent on nap-of-the-earth flight and vigorous maneuvers which tend to be highly provocative of simulator sickness.

The results of this analysis suggest that the rate of incidence of simulator sickness aftereffects is likely to be underestimated because of the survey procedures used. The survey procedures require long-term recall of incidents, and appear to underestimate the incidence rate of simulator sickness aftereffects by a factor of eight or more. If so, between 10 and 20% of pilots may still be prone to suffer aftereffect symptoms at 12 hours or longer. Survey results have been interpreted as indicating most pilots are "safe" after these times, and they have been proposed for incorporation into regulations. The conflicting data raise questions about this presumption.

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Appendix A

Page Extracts from Simulator Sickness Surveys Reflecting Identification Required of Participants

(Cover Page Example)

Serial No.______________ Date___________

SIMULATOR SICKNESS SURVEY

This is a survey of simulator aftereffects being conducted for the U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, in cooperation with the Naval Training Systems Center. The purpose of the survey is to determine the incidence of simulator aftereffects such as nausea or imbalance occurring in visually coupled flight simulators (UH-60, AH-1, CH-47).

We appreciate your cooperation in obtaining information about this problem. The results of the study will be used to improve the characteristics of future simulators. Your responses will be held in confidence and used statistically. Although we ask for your name on this page, no information will be reported by name. This cover page will be removed and all data will be identified by the coded serial number above.

Your Name___________________________ Rank________________________

Date________________________________ Unit________________________

Instructor___________________________(if in Qualification training)

Training Stage: Qualification________ Continuation_______________

Refresher ________ APART______________________

Mission ________

- -

(Survey Page Example)

Serial No.______________ Date_____________

POST-FLIGHT SYMPTOM CHECKLIST

Instructions: Circle below if any symptoms apply to you right now.

1.	General discomfort___________	None	Slight	Moderate	Severe
2.	Fatigue_______________________	None	Slight	Moderate	Severe
3.	Boredom_______________________	None	Slight	Moderate	Severe
4.	Drowsiness____________________	None	Slight	Moderate	Severe
5.	Headache______________________	None	Slight	Moderate	Severe
6.	Eye strain____________________	None	Slight	Moderate	Severe
7.	Difficulty focusing___________	None	Slight	Moderate	Severe
8.	a. Salivation increased______	None	Slight	Moderate	Severe
	b. Salivation decreased______	None	Slight	Moderate	Severe
9.	Sweating______________________	None	Slight	Moderate	Severe
10.	Nausea________________________	None	Slight	Moderate	Severe
11.	Difficulty concentrating______	None	Slight	Moderate	Severe
12.	Mental depression_____________	No	Yes		

Appendix B

Guidelines for Reducing Simulator Sickness and Aftereffects Risk

GUIDELINES FOR REDUCING SIMULATOR SICKNESS AND AFTEREFFECTS RISKS

General

o Arrive fully fit.
o Avoid prior conditions conducive to motion sickness.
o If medically grounded, use the simulator, but expect the possibility of simulator sickness symptoms.
o Simulator adaptation occurs, expect to re-adapt.
o Plan training sequence to minimize sickness potential.
o Through adequate preparations, simulator sickness can be reduced.
o Medical assistance should be sought if the problem persists.

Planning for Simulator Use

o Be aware of your susceptibility to simulator sickness, and plan accordingly.
o Separate simulator periods by at least 3 to 6 hours; preferably 2 to 5 days.
o Alternate pilots and training periods.
o Inform operator of any susceptibility to simulator sickness.
o Fly least provocative tasks first; most provocative last.
o Avoid starting with high visual flow rates.
o If eyestrain is a problem, schedule mornings.
o If headache or fullness in head is a problem, schedule afternoons.
o Select low detail areas for ICs.
o If sickness is a problem:

- Limit peripheral vision flow by blocking side window.
- Block lower portion of side window.
- Decrease visual range.
- Turn off motion.
- Try night operations or IFR.
- Use rapid or slow flight control movements.

Entering and Bringing Up the Simulator for Training

o Cabin lights on.
o Visual system off or at least in level flight.
o Adjust seat to the design eye position for visual displays.
o Block any view of other seat displays.
o Block lower side windows, if required.
o Close eyes while coming up on motion.
o Avoid viewing image shifts/slewing when checking out initial conditions.

During Training in the Simulator

o Do not expect the simulator to exactly replicate the aircraft.
o Stay within the design eye envelope for the visual displays.
o Minimize large and/or rapid eye or head movements.
o Avoid fast scan of visual images, especially reversing directions.

- Perform provocative maneuvers near end of training.
- Scatter provocative maneuvers over the latter portion of the period.
- Communicate status of any symptoms, adjust maneuvers accordingly.
- Take a break when needed.
- Communicate intentions before changing simulator status (e.g., start, stop, freeze, scan, reset, or IC set).
- Close your eyes during a change in simulator status.
- Before leaving, insure that visual system is off or simulator is in level attitude.
- Turn cabin lights on.
- Remain aware of balance during simulator ingress or egress.

Following Simulator Training

- Avoid high-risk activities (such as flying, climbing, riding motor/bicycles, driving, or diving) for 12 hours if no symptoms occur during/after simulator training.
- If any symptoms occur, avoid high-risk activities until 2 days after they disappear.
- Don't leave area until simulator sickness symptoms subside.
- Use handrails to help maintain balance when leaving simulator building.
- Anticipate aftereffects.
- If you experience any aftereffects:

  - Be extra cautious doing any high-risk activity.
  - Avoid rapid head, eye and postural movements.
  - Avoid large moving scenes from self-motion, TV or movies.
  - Remain aware of balance on stairs, high places, upon closing your eyes or upon entering dark areas.